

CLAIMS

What is claimed is:

- 1 1. A distributed Bragg reflector (DBR) comprising:
2 a plurality of first material layers formed from a first material over a substrate
3 and separated by a corresponding plurality of gaps; and
4 an additional layer, where the additional layer supports the plurality of first
5 material layers at their periphery.
- 1 2. The DBR of claim 1, wherein the first material is indium phosphide
2 (InP).
- 1 3. The DBR of claim 1, wherein the gap is filled with air.
- 1 4. The DBR of claim 1, wherein the first material is chosen from the group
2 consisting of any material in the indium phosphide (InP) material system.
- 1 5. The DBR of claim 1, wherein the additional layer is a regrowth of the
2 first material.
- 1 6. The DBR of claim 1, wherein the first material is a semiconductor.
- 1 7. The DBR of claim 1, wherein the first material is a dielectric.

1 8. A method for making a distributed Brag reflector (DBR), the method
2 comprising the steps of:
3 forming a stack of epitaxial layers, the stack of epitaxial layers including
4 alternating layers of a semiconductor material and a sacrificial material;
5 covering the stack with a mask;
6 etching the mask to expose the semiconductor material and the sacrificial
7 material;
8 forming additional semiconductor material on the exposed semiconductor
9 material and sacrificial material to form a support layer; and
10 selectively removing the sacrificial material to form air gaps between the
11 remaining layers of semiconductor material.

1 9. The method of claim 8, wherein the stack is etched at an angle other
2 than perpendicular with respect to a major surface of the stack.

1 10. The method of claim 8, wherein the semiconductor material is indium
2 phosphide (InP).

1 11. The method of claim 8, wherein the sacrificial material is indium gallium
2 arsenide (InGaAs).

1 12. The method of claim 8, wherein the support layer supports the
2 remaining semiconductor material.

1 13. The method of claim 8, wherein the support layer is a regrowth of the
2 semiconductor material.

1 14. A vertical-cavity surface-emitting laser (VCSEL), comprising:
2 a substrate;
3 a distributed Bragg reflector formed over the substrate and including a plurality
4 of semiconductor material layers separated by air gaps;
5 an active region formed over the distributed Bragg reflector, the active region
6 including a current confinement region and a tunnel junction;
7 a second reflector formed over the active region;
8 electrical contacts associated with the active region and the distributed Bragg
9 reflector;
10 where the distributed Bragg reflector includes a support layer to support the
11 layers of semiconductor material.

1 15. The VCSEL of claim 14, wherein the semiconductor material is indium
2 phosphide (InP).

1 16. The VCSEL of claim 14, wherein the semiconductor material is chosen
2 from the group consisting of any material in the indium phosphide (InP) material
3 system.

1 17. The VCSEL of claim 14, further comprising an additional
2 semiconductor material layer formed between the active region and the second
3 reflector.

1 18. The VCSEL of claim 14, further comprising:
 2 an air gap located adjacent the active region;
 3 a conductive layer located between the air gap and the second reflector; and
 4 an additional set of electrical contacts associated with the conductive layer, the
 5 additional set of electrical contacts configured to receive an electrical signal and alter
 6 the light output wavelength of the VCSEL by causing the conductive layer to move in
 7 response to the electrical signal resulting in a tunable VCSEL.

1 19. The VCSEL of claim 14, wherein the second reflector is an air gap
 2 supported distributed Bragg reflector.

1 20. The VCSEL of claim 14, wherein the second reflector is a dielectric
 2 distributed Bragg reflector.

1 21. The VCSEL of claim 14, wherein the support layer is a regrowth of the
 2 semiconductor material.

1 22. A method for making a vertical-cavity surface-emitting laser
2 (VCSEL), comprising:
3 forming a substrate;
4 forming a distributed Bragg reflector over the substrate, the distributed Bragg
5 reflector including alternating layers of a semiconductor material and a sacrificial
6 material;
7 forming an active region over the distributed Bragg reflector, the active region
8 including a current confinement region and a tunnel junction;
9 forming a second reflector over the active region;
10 covering the distributed Bragg reflector, the active region, and the second
11 reflector with a mask;
12 etching the mask to selectively expose portions of the semiconductor material
13 and the sacrificial material;
14 forming additional semiconductor material on the exposed portions of the
15 semiconductor material and sacrificial material to form a support layer associated with
16 the distributed Bragg reflector;
17 selectively removing the sacrificial material to form air gaps between the
18 remaining layers of semiconductor material; and
19 forming electrical contacts associated with the active region and the distributed
20 Bragg reflector.

1 23. The method of claim 22, wherein the distributed Bragg reflector and the
2 second reflector are etched at an angle other than perpendicular with respect to a
3 major surface of the VCSEL.

1 24. The method of claim 22, wherein the semiconductor material is indium
2 phosphide (InP).

1 25. The method of claim 22, wherein the sacrificial material is indium
2 gallium arsenide (InGaAs).

1 26. The method of claim 22, wherein the semiconductor material is chosen
2 from the group consisting of any material in the indium phosphide (InP) material
3 system.

1 27. The method of claim 22, wherein the additional semiconductor material
2 supports the remaining semiconductor material.

1 28. The method of claim 22, further comprising forming an additional
2 semiconductor material layer between the active region and the second reflector.

1 29. The VCSEL of claim 22, further comprising:
2 forming a layer of additional sacrificial material adjacent the active region;
3 forming a conductive layer over the additional sacrificial layer;
4 selectively removing the additional layer of sacrificial material to form an air
5 gap between the active region and the conductive layer; and
6 forming an additional set of electrical contacts associated with the conductive
7 layer, the additional set of electrical contacts configured to receive an electrical signal
8 and alter the light output wavelength of the VCSEL by causing the conductive layer to
9 move in response to the electrical signal resulting in a tunable VCSEL.

1 30. The VCSEL of claim 22, wherein the second reflector is an air gap
2 supported distributed Bragg reflector.

1 31. The VCSEL of claim 22, wherein the second reflector is a dielectric
2 distributed Bragg reflector.